

High Tech in the Deep South: Biomedical Firm Clusters in Metropolitan Atlanta

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Walcott, Susan M (1999) "High Tech in the Deep South: Biomedical Firm Clusters in Metropolitan Atlanta". *Growth and Change: A Journal of Urban and Regional Policy* 30(1):48-74.

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Abstract:

The relation between biomedical firms and their metropolitan region location in Atlanta, Georgia is examined as an empirical test of both innovative milieu agglomeration theory and place specific strategies for life science companies in the Deep South. This sectoral analysis utilizes questionnaires and targeted interviews to highlight the economic development role of real estate in suburban employment and residence sites (SEARS) and the intra-metropolitan directional migration of firms. Clustering of related industries is fostered by a shortage of appropriately configured laboratory and office space at the intermediate stage of the business growth cycle, encouraging information sharing and cooperative behavior via proximity by necessity. Lack of a key networking individual or mediating organization critically retards development of this potential growth engine.

Article:

Agglomeration Characteristics and Atlanta's Health Cluster

Biomedical firms¹ comprise a dynamic, high-growth subset of high technology, but place characteristics of the environments in which they flourish have been inadequately investigated by economic geographers. Entrepreneurial regions hungry to enhance their tax base are eager to understand the dynamics of clustered high technology firms with their well-compensated labor (Hall and Markusen 1985; Nojonen et al. 1993), but the locational needs of the biomedical complex are virtually ignored in academic literature. Research universities with strong faculties in the life sciences and affiliated hospitals are inadequate in themselves to generate successful commercial ventures, as illustrated in a study of Johns Hopkins and Baltimore. A "social structure" supportive of innovation must be created and nurtured to complete the process of building a dynamic cluster (Feldman 1994). This framework needs to be further extended and inhabited by people with personal location considerations, as illustrated in the following research.

The purpose of this research is to examine how biomedical firms are attracted and bound to a region, to their location within it, and to each other. Agglomerations of companies are generally divided into clusters of businesses tied primarily to place location factors (firm-region, as in the Silicon Valley innovative milieu) or to each other (firm-firm, as in companies who locate close to a production chain supplier, competitor, or affiliate). The strongest bonds embedding firms to an area involve both types (Glasmeier 1988; Malecki 1991; Saxenian 1994). Ties between firms develop synergistic partnerships in mature agglomerations through untraded interdependencies in the form of labor skills, sector specific services, tacit knowledge, and growth of venture capital (Storper 1997).

This research considers the development and implications of the firm-region location tie at an early stage in the agglomeration process when firms graduate from the initial innovation stage and choose to locate in a position suitable for product development and market entry positioning. The evolution of biomedical clusters and the movement of firms within the region as they grow are related. Agglomeration theories that differentiate among different stages of the firm life cycle, particularly genesis and growth (Markusen et al. 1986), assist in analyzing

the case of Atlanta. Malecki's (1991) addition of an "innovative cycle hypothesis" to account for process stages is a particularly useful refining improvement on the product cycle hypothesis.

Little agreement exists on prioritizing place and production process characteristics needed for successfully developing a high tech economic engine. Scott and Storper (1987) divide theories on geographic factors of high tech industries into "seedbeds" (or "innovative milieu"), product cycles, and locational lists, to which they add organization processes and the social division of labor. Theoretical types of agglomerated industrial districts are classified both by the processes at work (Malmberg 1996), from locally integrated networks to far flung *filières* (production chains of up and downstream suppliers and markets), and by the types of products produced (Park 1996).

Theories and case studies of economic development strategies abound; the crucial choice for analysts is to match a particular industry and a specific region (Goldstein and Luger 1993). The spaces in which high technology firms exist have been characterized as "technopoles" in a "new industrial space" (Castells 1985; Castells and Hall 1994). An environment of "co-operative competition" is also seen as necessary for the requisite "knowledge accumulation effects" (Malmberg et al. 1996, p94). An eclectic mix of agglomeration theories (Hall 1990) customizes the match between various industries and settings. Atlanta's locational advantage is not built on innovative technology transfers, unlike regions featured more frequently in literature on high tech (Pollard and Storper 1996).

Research questions focus on the location decision criteria of companies in Atlanta's biomedical complex and ramifications at different geographic scales: why Atlanta in the South? why that location in the metropolitan area? and finally what interactions occur because of the particular company location? Related issues explored include the impact of Atlanta's transportation infrastructure, the role of suburbs in providing attractive settings for residence and convenient employment, and the importance of contiguous location for company interactions. High technology agglomeration theories and their application to the Atlanta biomedical cluster are first assessed. Impacts of labor and real estate considerations on health industry restructuring are next highlighted, with particular emphasis on the development of suburbs as employment and residence sites (SEARS) combating out-dated misperceptions of inadequate schools, housing, amenities, and infrastructure throughout the South. Use of this acronym deliberately invokes suburban images of standardization, implying a reassuring homogeneity of product and process quality and dependability soothing the adjustment of mobile new resident-employees. The role played by geographic proximity (Porter 1994), both between firms and ties of a firm to a particular region, are examined sector-by-sector. Related components are linked in this study, such as custom plastics with medical devices, university technology transfers with science parks and *techubators*, where novel ideas with technological applications are nurtured in a dedicated facility. Conclusions extend cluster theory to include the ability of regional political-economy actors to construct advantages.

Data and Methodology

Examination of the locational choices and consequent spatial interactions of Atlanta's biomedical firms began with determining who and where such companies are. A geocoded map was created to display the location, on a basemap of the twenty county Atlanta Metropolitan Statistical Area (MSA), of firms affiliated by SIC codes. A combination of data sources was utilized since each data source added a number of companies to the list. The *American Business Directory* (1997), a nationally syndicated service, provides statewide information based on yellow page telephone book listings. The *Georgia Manufacturing Directory* (1997) is published by the Georgia Department of Industry, Tourism and Trade, and is similar to the commercial manufacturing-restricted *Harris Directory* published for each state. The membership roster of the Georgia Biomedical Partnership (GBP), as well as a list of eligible non-members drawn up by the association, supplied additional listings of local firms. Further leads and identification of companies was provided in the course of interviews with biomedical firm chief executive officers (CEOs), human resource directors, and other respondents. As demographic and commute considerations began to emerge from the interviews as location considerations, census tract data from the 1990 U.S. Census also was geocoded onto a regional base map.

In order to determine *why* companies located in these particular areas, survey forms were sent to all 171 firms identified in the combined records as biomedical complex members. Recipients were given a page of questions that could be answered quickly by a check, circle, or number. Space was also provided for lengthier responses if desired. Questions included why the company was at its current Atlanta location, whether it was a relocation or branch extension and from what state. To capture transportation considerations suggested in the literature, other questions concerned average distance from suppliers and markets, and commute-to-work considerations for management and other employees. Questions explored the degree of difficulty experienced by employers in finding different skill levels of employees, in order to assess the sufficiency of the local labor base and regional draw. Other questions probed the types of companies in the Atlanta area with whom biomedical firms do business, in order to assess the amount of local interaction. Companies were asked to circle their sectoral and county affiliation for categorization purposes.

Surveys were sent out twice, with a follow-up cover letter and a request to forward to the most appropriate person. More than a dozen surveys were obtained following a meeting of the Georgia Biomedical Partnership (GBP). The purpose of the research was explained, and an offer made to trade their completed survey form for a displayed copy of a geocoded map based on data showing location of firms identified by four sectors. Industry consultants were particularly interested in the map and indicated that their clients were requesting this type of analysis. Attendance at GBP meetings provided critical access to conversations about industry concerns.

The researcher conducted an additional twenty-five in-depth interviews with representatives of all target sectors. These included three custom plastic extrusion manufacturers (in relation to medical device manufacturers), three major technology park developers (to explore the role of real estate and contractors - predicted in the literature to drive Atlanta area development), and three different county economic development officials. Names of individuals to interview began with a list recommended by the head of the GBP as important and likely to be cooperative. This list expanded, as each respondent was asked to name someone else who should be contacted, or trimmed through lack of response. "Cold calls" yielded a more representative sample of conversations from each sector and metro area. Interviews were held by the interviewees choice either at their place of business (researcher's preference) or over the telephone. Several informative plant tours resulted following on-site conversations, which were always longer and more candid. Capturing the insights and viewpoints of individuals actively involved in promoting the biomedical cluster is crucial to understanding the location decision for companies (Schoenberger 1991).

TABLE 1. LIFE SCIENCE INDUSTRY: ATLANTA

SIC Code	Business	Firms	Employees	Interviews
2833-6	Pharmaceutical/Biotech	26	5,547	9
3841	Surgical and Medical Devices	25	1,660	6
8071	Medical Laboratories	88	4,000	2
8731-01	Research & Development	32	1,250	2
	Developers			5
	University			2
	Government Entity			1
	Other			1
TOTAL		171	12,457	29

Analysis: Spatial Impact of Health Complex Restructuring Strategies

This study followed inquiry into three basic research questions: why in general did biomedical firms locate in the Atlanta region? why in their particular company location? and what interactions with other firms occurred due to the location decisions? Responses to both the survey and interview formats are similar, so they were merged for the following analysis. Interviews supply additional details. Responses are broken down into labor and real estate factors for further discussion, as these emerged as the critical considerations for this region. Interview and survey results are based on a total of 68 responses (a 40 percent return rate), composed of 43 questionnaires in usable form and 29 interviews conducted with corporations (19), government planners (2), real estate developers (5) and others (3). The number of firms and employees in each sector is shown in Table 1, as are the numbers of individuals interviewed in each sector.

Details on responses to key topics are given in Table 2, divided into categories by response tool. Totals varied since some questions were on the survey form but explored more fully in the interview format, such as the nature of the relation with colleges and universities (overwhelmingly as a labor supplier), and principal unmet needs (evenly divided between more venture capital and more biomedical companies). Variation also comes from many questions that were skipped on some, answered on others. Included in the survey and interview, but not in Table 2, are cross-checking questions, such as the importance of airport facilities which was addressed in two different questions. The survey also asked companies to indicate how many years (within given ranges) they have been in Atlanta (varied widely), and size by number of employees (usually either small or large). These often were skipped; responses did not vary by size or duration of business.

TABLE 2. ATLANTA LOCATION DYNAMICS

Response Category	Interview	Survey	Total
1. WHY ATLANTA?			
Incubator/tech transfer	6	6	14
Tech park/land available	8	4	12
Airport	8	29	37
Quality of life	3	6	9
Southeast growth region	2	2	4
Merger	4	2	6
CEO ties	5	2	7
2. NEARBY COMPANIES?			
Sublet	6		6
Main customer nearby	3		3
Swap labor	4		4
Spin-off/merger	4		4
Share discussions	4		4
Do some business	3	10	13
3. LABOR BASE ISSUES?			
Hard getting technical workers	8	20	28
Top tier want good quality of life	10		10
Good access to top talent	8		8
Two tier labor pool	3		3
4. REAL ESTATE ISSUES?			
North of Perimeter	20		20
Facilities for intermediate stage	16		16
County inducements	3		3
Land affordable	6		6
Live near management	8	25	33
5. EFFECT OF ATLANTA LOCATION?			
Close to universities	6		6
Good weather	22		22
Poor collegiality	5		5
Concern re. Education, South image	4		4
Affordable, high quality living	10	20	30
Good labor base, critical mass	4		4
City as telecom, commerce base	6		6
Entrepreneurial opportunity	4		4
Commute problems: Management/employees	2/4	10/26	42
6. BUSINESS W/OTHER COMPANIES?			
Pharmaceutical	5	13	18
Hospital	3	15	18
University	15	2	17
Medical device	3	7	10
Research and Testing	6	20	26
Chemical	2	6	8
7. YOUR COUNTY?			
Cobb	6	10	16
DeKalb	3	7	10
Fulton	3	6	9
Gwinnett	10	12	22
Other	7	2	10

Location factor responses are grouped further under six major categories (Figure 1). The heading "personal real estate" includes quality of life factors such as commute, schools, and affordable housing. The "transport link" category overwhelmingly reflects the desirability of Hartsfield International Airport's frequent flights and extensive routes. Modern shipment requires only proximity to busy airports or interstate highways. Locating the office and home along the most time efficient path is a priority consideration in the firm location decision. "Business real estate" factors include the availability of adequate facilities or land on which to build, and

considerations stemming from the lack of such facilities, leading for example to subletting from a potential business partner. Tech transfers were from four of the area's research universities: the University of Georgia in Athens, Georgia Institute of Technology, Georgia State University, and Emory Medical School in Atlanta. "Other company factors" include spin-offs, mergers, trailing partners, and proximity to Atlanta-based facilities such as the Centers for Disease Control.

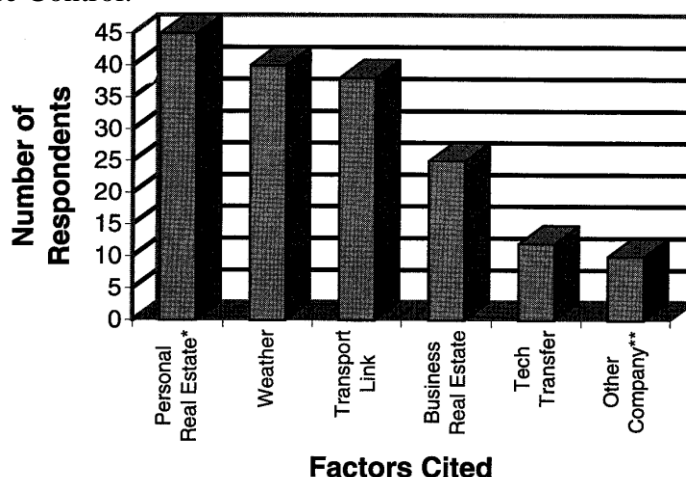


FIGURE 1. LOCATION FACTORS FOR BIOMEDICAL BUSINESSES IN ATLANTA
Source: Author Interviews and Questionnaires

The geography of biomedical-related companies in the area as revealed in address-matched maps shows a strong tendency toward spatial clustering (Figure 2). This base map indicates all counties in the Atlanta region with biomedical firms, while other maps in this study reflect the Atlanta Regional Commission's (ARC) designation of ten metro counties (compared to the official MSA of 20 counties). Occasionally Forsyth County's location along Route 400 pulls economic activity into its orbit, necessitating its inclusion in a regional map. The predominant spatial pattern of biomedical companies demonstrates the attractiveness of major arterial interstates outside highway 285, a major road circling Atlanta frequently referred to as "the Perimeter." Vance's "Urban Realms" model (1977) predicted the rise of accompanying suburban mini-cities, noting that concentrations of firms tend to develop around a regional transportation network. The location of the city's three largest clusters of pharmaceutical firms and medical device manufacturers indicates the importance of interstate accessibility: in the northwest along I-75 in mid-Cobb County, northeast along I-85 in mid-Gwinnett County, along GA 400 in north Fulton County outside the perimeter highway Route 285, and along the central I-75/85 "Connector" portion of merged interstates. The cluster along the Connector is the high tech business incubator on the Georgia Institute of Technology campus, referred to in this research as a *techubator*. Companies overwhelmingly indicated a strong preference to be north of the Perimeter for reasons explored later. Atlanta is clearly divided into distinct sectors north of Route 285. The existence of infrastructure such as major transportation arteries is important (Feldman and Florida 1994), but the pronounced shift northward for location of both companies and population indicates that direct proximity to the southside airport is less important than timely accessibility (*Atlanta Journal-Constitution* 1997).

A defining economic characteristic of the new suburb is the spatially proximate linkage between place of residence and employment. This section is therefore divided into interlinked subcategories reflecting either primarily personal or business considerations impacting on the location decision. Fishman (1987) forecast "technoburbs" would lead to the "death of suburbia," based on workers' aversion to the ever-lengthening commute between center city jobs and bedroom communities. The predicted demise of both suburbs and commutes did not occur; jobs just shifted increasingly north of the city to suburbs where employees and owners lived, putting pressure on infrastructure in newly dense areas. Innovative start-ups migrated from their initial closest proximity to critical factors (university, techubator, and airport) to larger, more distant, and mechanized facilities.

It is impossible to over-exaggerate the impact of Atlanta's highways on the location decision. Roads originally designed to carry suburban dwellers to city jobs and shops are now completely incompatible with current cross-county commute patterns. A metropolitan area such as Atlanta is better characterized as a "pepperoni pizza" (Hartshorn 1989), with multiple centers of economic activity in autonomous towns, between which the commuter shuttles on the daily journey to work. The central corridor of Route 400 marks an asphalt continental divide between firms to its eastern and western side, due to the daunting load of commute traffic on the perimeter highway and the lack of alternative east-west routes.

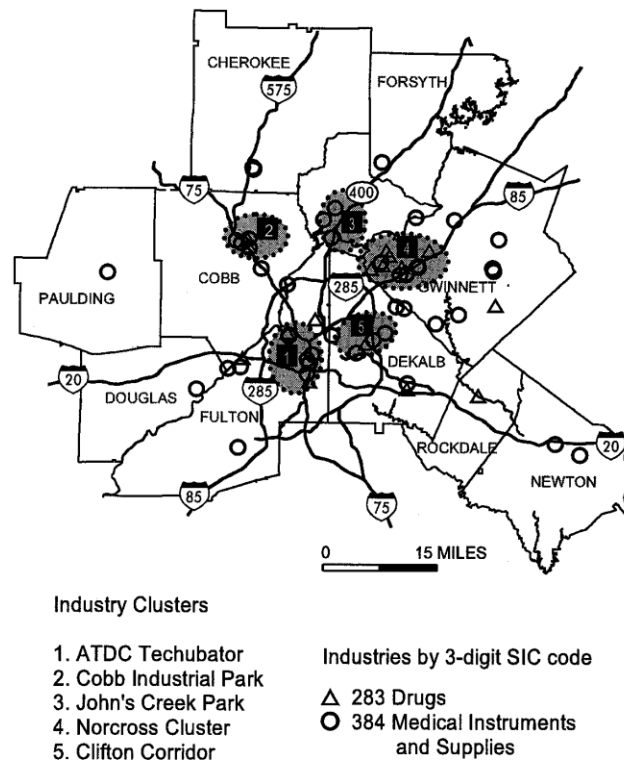


FIGURE 2. BIOMEDICAL COMPANIES IN THE ATLANTA MSA.

Source: American Business Directories. 1997. *Georgia Business Directory*. Omaha: American Business Directory; Georgia Department of Industry, Trade and Tourism and Georgia Biomedical Partnership. 1997. Survey of Georgia Biomedical/Health-related Industry Allies. Atlanta: Georgia Biomedical Partnership; author observations.

The Labor Factor and SEARS . Beyond its favorable Sunbelt location and famous boosterism, Atlanta provides transferable strategies demonstrably effective in overcoming outdated perceptions of an adverse "historic legacy" attached to the Deep South and its largest metro area. Characterizations of high tech regions miss the mark when dealing with and dismissing prospects in the South. History is replete with cyclical development periods of oscillating regional lead and lag times (Pavlik 1997). Atlanta led the nation from 1985-1995 as the metropolitan area attracting the largest number of in-migrants. It continues to do so, with a net migration inflow from 1990 to 1996 of 319,100 new residents (Frey 1997).

Movers are primarily college educated, white collar, and settle in the northern suburbs where most high tech firms congregate (U.S. Census 1990; County Business Data 1996; Lewis 1996). The location of metro area residents with graduate school level education (Figure 3) and in professional specialty occupations (Figure 4) reinforces a pattern of highly skilled labor coinciding with the locational concentration of biomedical jobs. The percentage of county residents employed in these sectors, compared to the total county employment base, is shown to indicate more clearly the regional concentration of this labor sector. Concentration is again to the north of the city, and especially in the northeast. Recently compiled data indicates Georgia was second only to Texas in the number of high tech jobs in general added to the total workforce between 1990-1996 (American Electronics Association, in Barry 1998).

Production process requirements impose crucial location factors. These include the availability of low and high skill labor, real estate, and capital infrastructure through both individual and institutional arrangements. The future of the South as the site for high tech industry growth is neither predicated nor limited by the competitive advantage of low wage and unionization rates. The success of attitude and legal changes in race relations since the 1960s is shown by migration of African Americans back to the South (Roseman and Lee 1998), the relatively small discrepancy in white and minority earnings, and high rates of minority college graduation (Frey 1997).

The growth of SEARS comprises a permanent part of the modern landscape (Hartshorn and Muller 1986, 1989; Muller 1997). Studies spanning two decades demonstrate the relatively high concentration of workers in high tech and high paid jobs in the suburbs (Stanback and Knight 1976; Herzog 1986; Stanback 1991; U.S. Congress 1995). The location pattern displayed by Atlanta area firms in high tech sectors such as electronics, computer software, and tele-communications, is strikingly similar in its concentration north of the Route 285 Perimeter, and in particular northeast of the city of Atlanta, to those of firms in the biomedical field (Figure 5). Clearly, the health complex fits within the locational pattern of metropolitan area high tech firms.

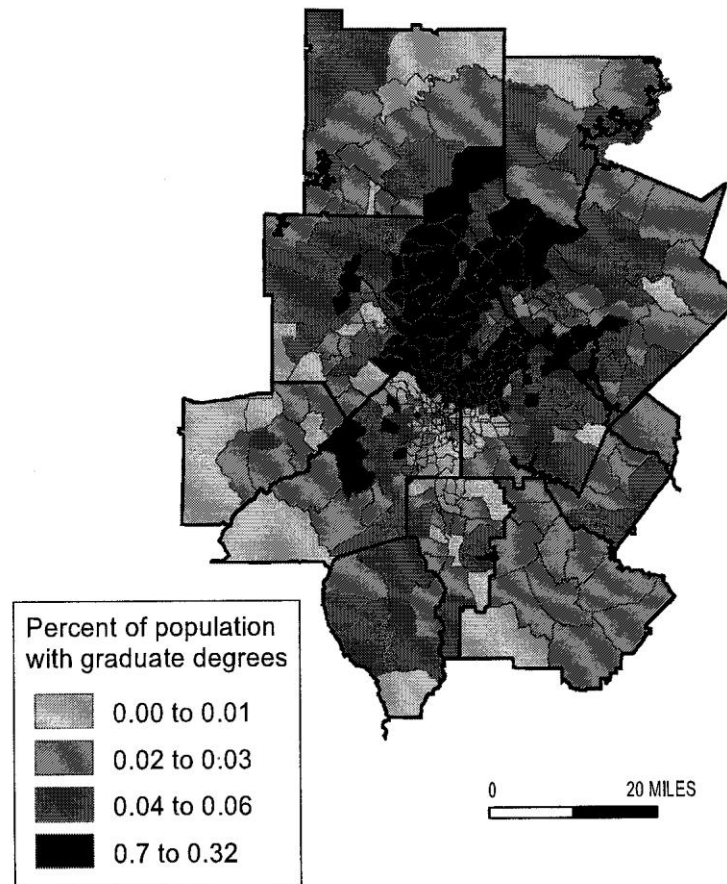


FIGURE 3. PERCENT OF POPULATION WITH GRADUATE DEGREES.
Source: U.S. Bureau of the Census. 1990. *Characteristics, Georgia*.
Washington DC: U.S. Bureau of the Census.

The labor market for the biomedical industry is typically segmented into three basic skill levels, where different attraction and retention considerations apply for management, technicians, and high school graduate level employees (Gordon 1994). The residential location preferences of top corporate employees (combining the first two levels) play a critical role in the corporate location decision—owners because they make the choice, and technical employees because the ability of companies to attract them is a key competitive factor. According to both survey and interview results, employment site decision-makers clearly chose a location to suit their own commute convenience and that of the most skilled employees. Agglomeration functions as a career enhancing

labor base enticement by increasing the possibility of job mobility within the same region, reducing the social and financial costs of a move if a job does not work out.

The residential location of the lowest paid workers is not an important factor in the location decision. The lower skill and pay level of the “social division of labor” (Scott 1988) is composed of high school graduates and “General Education Degree” holders. With some rudimentary work attitudes such as diligence, this labor segment can fill a spot on the robotics floor of a flexible manufacturing or low end mechanized biomedical-related factory. With the shift of high level employees to suburbs pulling firms along with them in that direction, the geographic source area for employees at the other end of the pay scale has changed as well, with far-reaching implications.

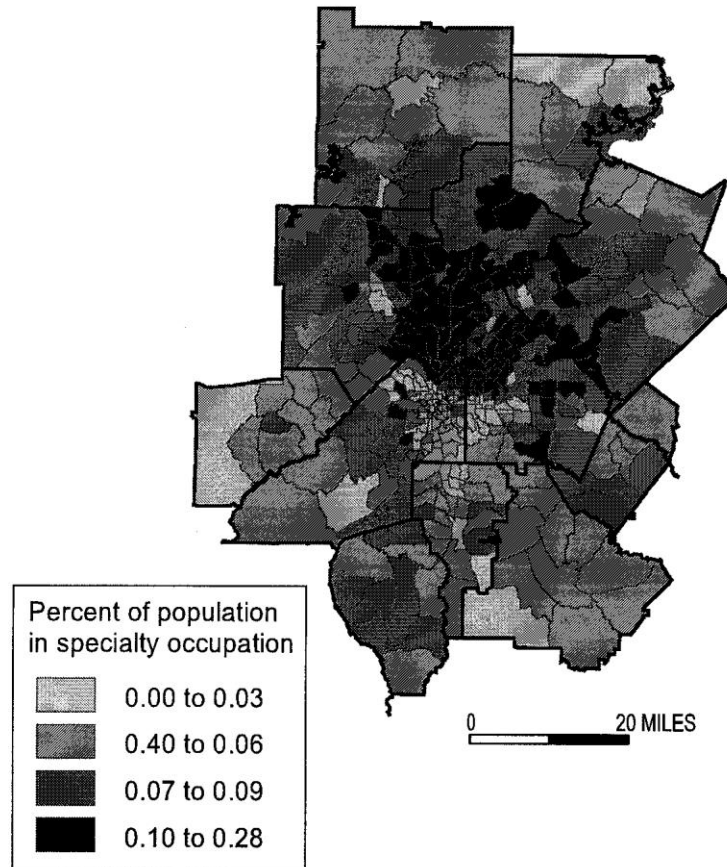


FIGURE 4. PERCENT OF POPULATION IN A PROFESSIONAL SPECIALTY OCCUPATION IN THE ATLANTA MSA, 1990. Source: U.S. Bureau of the Census. 1990. *Characteristics, Georgia*. Washington, D.C: U.S. Bureau of the Census.

Outlying rural rather than inner city urban areas supply low wage labor to new areas of manufacturing, according to a number of interviews. The movement of labor from rural areas to non-farm jobs was predicted, especially in areas bordering high technology and research-rich areas (Rosenfeld et al. 1982). New industries utilizing computerized rather than mass manufacturing employ some (but far fewer) of these workers, specifically for the Southeast (Furuseth 1992). Related problems, such as reliance by many in this labor force sector on public transportation for the journey to work, continue to concern human resource directors. Firm location in an outlying suburb or exurb draws on a local workforce, worsening the worker mobility problem due to lack of frequent and affordable mass transit routes. The shift of lower skilled labor source areas to rural peripheries rather than the inner city assists employment for one spatial (and often demographically distinguishable) sector at the expense of another.

Real Estate Factors. Studies of the location of high technology firms, such as those involved in biomedicine, generally find a distinct need exists for companies to be close to universities and research centers, particularly in

the beginning (Kenney 1986; KPMG 1993). In the genesis stage, inventions have a strong commercial propensity to migrate from laboratory to market.

The expense and difficulty of acquiring laboratory facilities for biomedical research, the lengthy testing and approval process, and the extremely profitable nature of successful inventions, all combine to create an attractive tendency for university researchers to leave academia in order to launch entrepreneurial ventures following a promising breakthrough (Audretsch and Stephan 1996). In order to retain personnel and capture some profits from their inventions, while permitting cutting edge innovations to come to the marketplace, government and academic institutions have generally encouraged mechanisms for permitting technology transfers from laboratories to private enterprises (Kenney 1986).

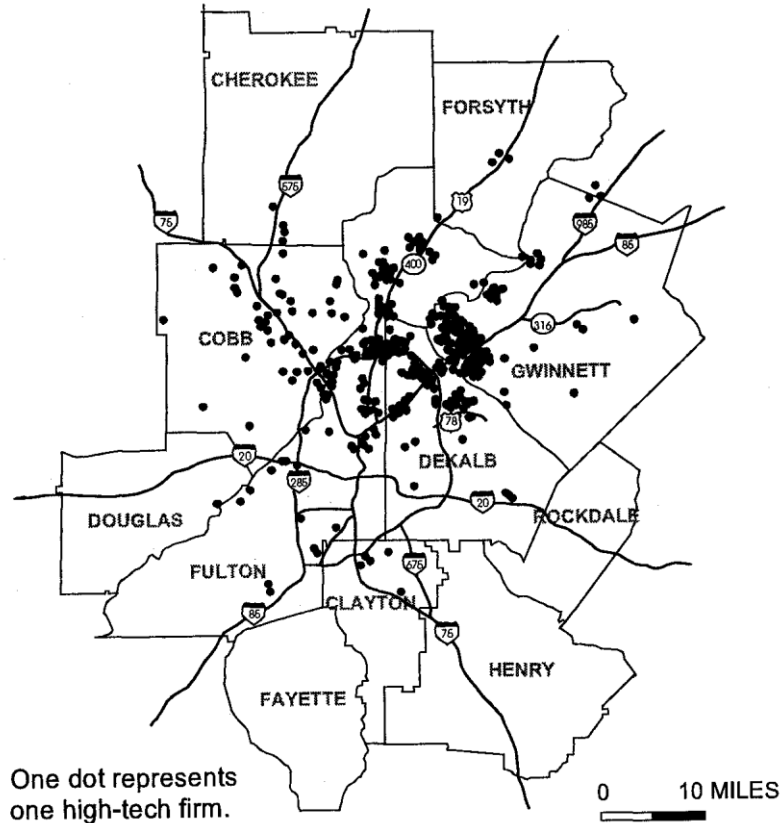


FIGURE 5. METRO ATLANTA'S HIGH-TECH HOT-SPOTS.

SOURCE: GEORGIA DEPARTMENT OF INDUSTRY, TRADE AND TOURISM

Several large firms in Atlanta successfully pushed a proposal to assemble a specifically biomedical incubator to quickly attract and sustain more startups, replicating conditions at the Advanced Technology Development Center (ATDC). Created in 1980 near the Georgia Tech campus, the ATDC forges the techubator link in Atlanta under the auspices of the University System of Georgia (Stone 1997). Government public-private intervention is most active at the starter phase of a biomedical business. Techubators are often on the campuses of or maintained in conjunction with universities. According to records kept over the last four years, six companies clearly identified as biomedical graduated from the ATDC facility.

The competitive need to be at the cutting edge of innovation continues the advantage of being close to centers of experimentation during the growth stage. The level of research and development in products, size of the plant, and the organizational structure of the firm also affects linkages and spin-offs promoting local growth (Glasmeier 1988). Some of the variety in Atlanta's biomedical locations is due to the youth of many firms and differences in their stage of development.

Examinations of urban high tech and biomedical centers such as Silicon Valley (Saxenian 1994) and San Diego (Pryde 1992) point to the influence of large, well-endowed research centers such as Stanford, Salk and Scripps

allied to hospitals and universities. Also present in these cities are large corporate anchors which employ graduates, absorb tech transfers, spin-off or circulate labor pools. In the Atlanta MSA this function is in part performed by hospitals affiliated with Emory University. The closest Emory-corporate-biomedical connection is with Coca-Cola and the Centers for Disease Control and Prevention (CDC). At the end of World War II Coca Cola's then-CEO was instrumental in convincing the federal government to establish the CDC on land adjacent to the Emory campus donated by Coca Cola. Coca Cola continues to support this with generous grants in several forms (*Atlanta Journal Constitution* 1986). Some companies specified they came to Atlanta because of the CDC; this desire for proximity is reflected in the "Clifton Corridor" strand of biomedical companies along Clifton Road where both the CDC and Emory University Hospital are located in the DeKalb cluster.

Concentrations of firms engaged in similar businesses occur in science and industrial parks on the urban periphery (Figure 6), indicating the importance of specially configured real estate in anchoring economic activity (Hartshorn 1973; Taylor 1985). Both product cycle and regional specialization theory characterize health complex clusters as growth poles affiliated with science-industrial parks (Rees and Stafford 1986). The development of office parks and space especially designed for biomedical research and production is one of the clearest real estate-related explanations for the clustering of biomedical firms in metro Atlanta.

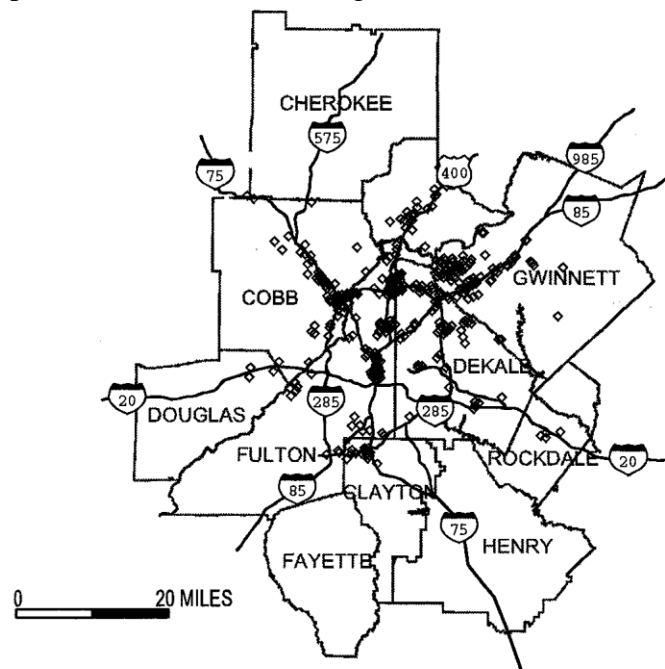


FIGURE 6. METRO ATLANTA OFFICE AND BUSINESS PARKS. Source: Map modified from Frank Drago, *Metropolitan Atlanta Office and Business Parks*.

Technology Park in northeastern Gwinnett County features the most prominently successful concentration of high tech companies in Atlanta. This tract is part of a large regional cluster of high tech companies around the town of Norcross, referred to locally as "The Norcross Cluster." Opened in 1971, Tech Park forms the core of the northeastern Atlanta area high tech job creating sites. Designed amenities include lakes, forested surroundings, retail and service firms, and various types of upscale residences. The current Tech Park president maintains that technology is foremost a people business. Developers catering to this market assume that highly paid and high demand workers want attractive offices, exterior space for contemplation, nearby quality residences, high achieving schools, and family-centered amenities (Gruen et al. 1995). The market place reflects this assessment with rising prices and housing stock for this niche.

The cost of land rent alone does not explain firm concentrations at major locations in the Atlanta MSA (Figure 7). Areas of least cost facilities do not correspond to the highest concentrations of companies. The first stop out of a government-subsidized business incubator in the "A" zone is north of the Route 285 perimeter (personal communications). The most desirable locations are also the most expensive "C" zones. The less expensive

northeast “C” zone is considered almost at full capacity. New development largely occurs in the most costly Route400 north central area, including a new “park within a park” development for post-startup biomed companies.

The need to sublet old space by expanding companies promotes even further agglomeration of biomedical activities. Suitable laboratory space configured for biomedical use, with presentable reception/administration space for customers, is difficult to obtain in the current real estate market. Developers may be leery of biomedical tenants, principally due to the nature of materials handled (animals or other biological substances), the speculative risks of most biomedical start-ups, and the perceived difficulty of reselling a highly customized office space. Most technology parks and university-connected incubators prefer “clean” customers such as software companies that require minimal mess or customized demands.

The tight office market in Atlanta in general exacerbates the shortage of appropriate spaces. Real estate considerations leading to “inheritance” of pre-converted facilities, particularly adjacent to potential partners, showed up most clearly in the intermediate office size sector. Availability of suitably configured offices, with specialized equipment needs and an attractive reception area for customers or funders is difficult to find. When facilities are outgrown, the market favors subletting them to a firm with similar needs while larger facilities or more adjacent offices are found for the original occupant.

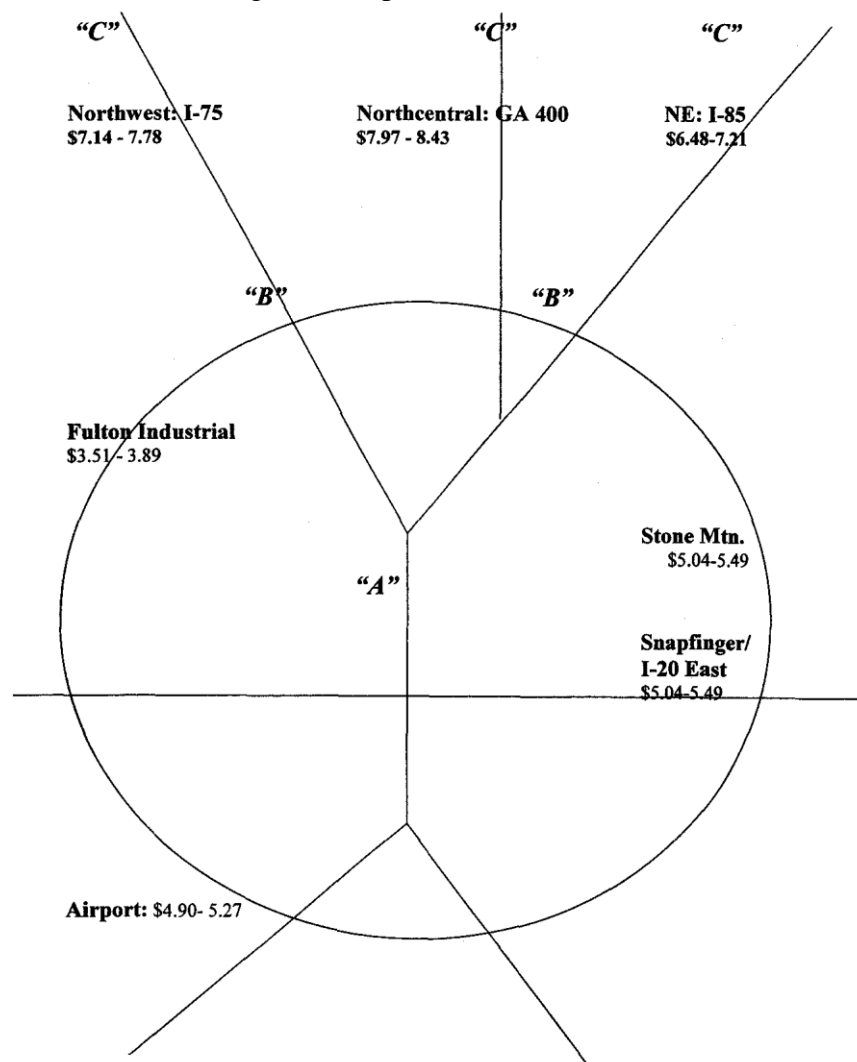


FIGURE 7. LOCATION SCHEMATIC: WEIGHTED AVERAGE RENTALS/SQ. FT.

Source: Dorey's Publishing and Information Services. 1997. *Dorey's Atlanta Office Guide*. Atlanta: Dorey Publishing.

Spatial needs critically are not addressed at the intermediate production cycle stage in Atlanta. This next stage of innovation commodification requires more space and specialized facilities. Clustering arises from the lack of suitably configured office space, and encourages inter-firm relationships to meet this need through subletting. A particular application of untraded interdependencies (Storper 1997) fosters inter-firm ties with a demonstrably spatial shape. The striking characteristic of firm interactions shown in the samples featured in Figure 8 is the amount that occurs among firms in the same section of the metropolitan region—and the paucity of cross-county ties. The number and location of firms portrayed is representative of the variety of arrangements revealed in extensive interviews—some of which were requested to be kept confidential. Predominance of firm evidence in the northeast mirrors the relative abundance of firms in that location, as demonstrated by previous geocoded address maps (Figures 2, 5). Inter-firm relationships were revealed in the course of extended interviews with CEOs and other designated officers. Agglomeration advantages from nearby locations play an important role in the frequency and nature of interaction reported to occur between companies in the biomedical cluster. Lines of intercommunication and the nature of the relationship between companies are affected by the location of participating firms. Agglomeration does not preclude transactions with those outside the immediate cluster, but it does encourage interaction. Companies feel a particular need to be close—not necessarily adjacent, but proximity is its own inducement, as detailed below.

Corporate Relationships By City Sector

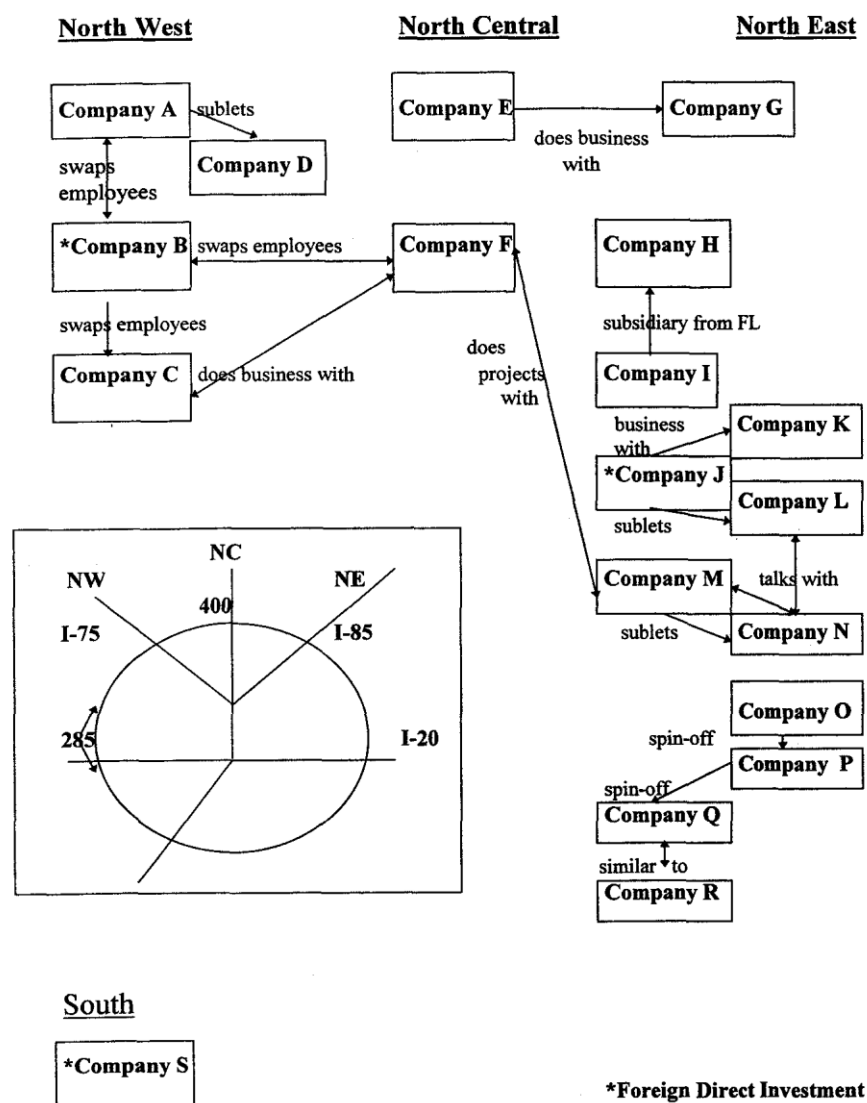


FIGURE 8. CORPORATE RELATIONSHIPS BY CITY SECTOR. *Source:* Author Interviews

Although some firms denied any local interaction more hotly than did others, virtually none are without some sort of connection to another nearby company. Reluctance to admit information or transaction interchange is symptomatic of Atlanta's independent businesses—even while often expressing a desire for more interactions.

Examples of creative space-based interactions abound, however. Two of the newest companies network with each other and with two nearby senior companies. Two subsidiaries from current companies have been created; space vacated by the less successful one provided a facility for another expanding company. One older firm in a peripheral location nevertheless uses the services of a locally headquartered nationally prominent medical laboratory. The two largest employers in the northwest sector experience employee switching, and look for more companies to increase the pool of locally available sector-specific trained labor. One locally grown giant telecommunications company created a biomedical firm to exploit a transferable laser technology. An enterprise moving further northeast nevertheless is sharing a new invention specifically with its current neighbors, in case they can put it to creative use.

The demonstrated directional migration of maturing firms within a region holds implications for retention of economic activity due to enduring regional attributes. These features, which also influence enterprise attraction, are the result of public policy at both the initial start-up phase and the mature embedding phase (Andersson 1985). Regional capacity to nourish innovative industries thus can be built as the result of conscious investments, overcoming development lags. Spin-offs from more mature life science firms are beginning to occur in Atlanta, but not all have survived. Atlanta's firms lack generational trees, displaying far more firm-region ties than the firm-firm variety many profess to want. Endogenous agglomeration advantages such as knowledge spillovers (Krugman 1991; Stephan et al. 1997) are apparent in Atlanta's biomedical complex, but their contribution to the local accumulation of knowledge (Malmberg et al. 1996) is muted.

Cluster Location Development of Firms by Type

Cluster patterns characterize Atlanta's biomedical landscape; cooperation or at least communication is highest within rather than between locational clusters. Each of the sectors reviewed below derives competitive advantage from innovations and computerization. Locational patterns range from medical labs and clinics ringing the city to provide quick access, pharmaceutical and device manufacturers in three northern locations, to major private hospitals perched on "Pill Hill" near the north central Perimeter-Route 400 intersection.

Pharmaceuticals. All of Atlanta's major pharmaceutical companies were interviewed for this research. Firms vary widely in size, age, and type of product. Pharmaceutical companies use both in-house and subcontract work to stay abreast of the latest research in a highly competitive, proprietary environment (Grabowski and Vernon 1994). Three of the most successful firms include a Belgian-owned, recently merged multinational that relocated its American headquarters to the Atlanta partner's location. Another company started in Florida but moved to the Atlanta metro region for access to better airport connections. A third merged and relocated to Atlanta due to the personal preference of its executive. They are in the same northwestern part of town and exchange both information and employees with each other.

Geographically convenient relationships include a potential medical device partner in the subleased quarters of one firm, and a custom plastics molder close to its main device manufacturer customer. Most intense activity occurs where the number of firms is greatest. Mere geographic propinquity does not guarantee a business relationship, however. Pre-established links with a more distant firm continue historic, trust, and experience based ties over the potential for a new relationship with a closer company when distance is not a crucial factor (interviews).

Medical Device Manufacturers. The manufacturing sector of the health complex is particularly varied and dynamic (Malecki 1997). Medical devices can be extremely profitable to manufacture despite competitive challenges based on the rush to develop new specialized equipment, long and expensive delays from conception to development and testing awaiting FDA approval (Duesterberg et al. 1994). This is also the most highly

agglomerated sector of the Atlanta health complex, and the only one displaying a certain (though reportedly still unsatisfactory) amount of firm-firm working together.

The type of medical device firms mirrors the changed position of the South as a region, and the industry as technologically sophisticated. Formerly a branch region, Atlanta now hosts national headquarters of global companies and firms serving international markets. The draw to Atlanta is tech transfer as well as visibility, which no longer means just the northeastern U.S. Leaders incorporate key innovative characteristics to sustain their growth (Hekman 1980). Companies are creative in their applications as well as initial product development. They respond not just to what the market needs, but consider what other applications they can teach customers to use.

Clustering of medical device companies is particularly prevalent in the Norcross tech and office park market in southwestern Gwinnett County. Proximity to both Georgia Tech to the west and the University of Georgia to the east enhances the desirability of this location, but the office market suffers from growth in demand exceeding affordable and desirable supply. Outlying parts of northern counties, particularly those areas near newly constructed desirable residential tracts, are beginning to attract successful firms looking to expand.

Custom plastic extruders are located close to their major customer, and in some cases came to Atlanta for that reason. In different metro north places enough business exists that spin-off of a firm in one part of the city can be established to serve medical device firms in another part of the north metro area. Medical device and plastic extruders are so closely linked to a key customer that spatial contiguity is not enough by itself to attract business. Links to automobile parts customers forge another international and intersectoral application of the same technology and manufacturing capability.

Medical Laboratories. Predominantly small medical laboratories are dispersed throughout the city, often to provide services for a designated health maintenance organization (HMO). The combination of computerization and increased drug testing and referrals expanded the demand for such services beyond local facilities. Beginning in the downtown area as a group of individual small labs operated by doctors in their affiliated hospital, many were bought in the late 1960s. For efficiency and control, a central headquarters testing and purchasing location was established in the former Pathology Services Physicians Association site. The original site selection came from a doctor affiliated with that group who purchased land in DeKalb County, close to where he lived in Lawrenceville, accessible to both Interstate 85 and the perimeter highway. The investment paid off. The motivation of speculative real estate for an individual's personal convenience proved to be an advantageous positioning for what is now a global corporation.

Hospitals. Access to basic research is the key reason for inter-firm connections, according to survey and interview responses. Cooperative use is often made of large research hospitals that serve both as markets and test sites. The most visible health care delivery structures on the landscape are towering hospitals and their surrounding campuses. Representing large sunk capital investments in a long standing system, hospitals face enormous challenges to their standard way of doing business—and a consequent need to reconfigure their built facilities. Cost-cutting pressures, enrollment in HMOs, and the requirement of pre-admission approval work together to dramatically reduce the need for hospital beds and lead to a consequent rise in demand for outpatient services. Competitive pressure to retain customers seeking conveniently located medical services also led to the building of numerous small satellite centers in inner city neighborhoods and to building affiliates in outlying suburban areas (Bargar 1991).

Ironically, adaptive construction continues at a furious pace in a time of belt-tightening budgets, as providers adjust their facilities to meet the new demand structure. The kinds of facilities built reflect demographic trends, HMO approved needs, and services the wealthier are willing to pay to obtain. These include geriatric units, birthing centers, more private rooms rather than shared facilities, intensive care units, psychiatric care, oncology centers, nursing centers, ambulatory (out-patient) surgery centers, and facilities for staff such as new cafeterias

and offices for administrators. Typically, plans were formulated some five years before construction actually began and scaled back as needs and funding changed.

Part of the rise in the cost of doing business as a hospital is the increasing availability and complexity of medical devices. New technology also minimizes the need for in-hospital services. A 1995 Texas study revealed an increase in the average number of biomedical equipment pieces used per licensed hospital bed from four in 1982 to ten by 1991 (Shaffer and Spring 1995). The proliferation in kind and quality of technology in this decade also made possible a tremendous rise in the number of patients treated off-site. Growth in home care products is predicted to be the fastest rising and most profitable future sector of the medical device market. Overall, relocations from less visible or dynamic areas, mergers with Atlanta firms, consolidations of disparate firms to headquarters in Atlanta, and to a lesser extent spin-offs and tech transfers, built the local biomedical concentration. Specialized business services such as venture capital, legal advice, and specially configured office and laboratory spaces are increasing but remain in short supply.

Conclusion

Spatial impacts of dynamic high technology clusters revealed in this research on the biomedical sector are broadly applicable to developments in metropolitan regions across the nation. Successful industries best match regional attributes in ways not fully appreciated in previous literature—which explains the diversity of theories attempting to describe high tech firms and regions. Atlanta's biomedical cluster is in the take-off stage, and a function of the city's preeminence in a dynamic region. The degree of interaction among firms is affected by the small number in the local cluster, diversity of processes, generality of the shared attraction factor, lack of a focused specialty, and the cluster's relative youth. All of these factors retard the creation in Atlanta of a life science agglomeration producing innovation-generating synergy from inter-firm collaboration (Rosenfeld 1992, 1996). Clustering occurs as the result of real estate considerations leading to proximity by necessity.

The critical bottleneck in Atlanta's attempt to develop its medical complex is not a lack of "pull" factors in a structurally well-equipped area, such as retard Rotterdam's development of a medical growth pole in a less desirable region of Europe (van den Berg and van Klink 1996). Development is impeded neither by the presence of particular "push" problems, nor structural shortcomings, but by the human element of leadership, both in networking organizations and a dynamic individual. The problem is one of nurture. Individual networks build on a regional milieu. Innovation-enhancing infrastructure is the result of long term careful construction (Feldman and Florida 1994). Firms fix to similar regional advantages, such as an airport. Advocates of "new industrial spaces" created by flexible specialization product and process innovations assert that "industries produce economic space" (Storper and Walker 1989). The Atlanta region study demonstrates that innovative industries fill space created for them by proactive agents and institutions, such as Technology Park's Georgia Tech alumni and influential venture capitalists. These spaces remain in short supply in Atlanta, given the potential for expansion in the region's life science industry.

Continuing growth of networked companies is sustained by regionally appropriate strategies. Local leaders are educable as to the needs of high tech companies, when spurred by more visionary agents offering a long-range vision of a highly lucrative potential outcome. Particular contributions of this research include highlighting the economic development role of SEARS, designed to reassure the relocated migrant that civilization as they knew it continues in the suburban South. In a heavily congested commute area, proximity of office to residence of top management is a persuasive feature supporting the ever-northward directional migration of firms.

Areas for further examination include more detailed study of the nature and interrelationship of each part of the biomedical complex. Broad sectoral inter-linkages at this juncture of health industry restructuring need to be integrated in research. Atlanta's situation should be contrasted with firm configurations in other regions of similar scale on the national urban hierarchy. Restructuring of labor sources, from the inner city to rural and suburban fringe locations, continues to raise questions with implications for transportation, education, the evolving metropolitan political economy, and quality of life.

NOTE

1. Biomedical firms comprising the life science industry in this research include pharmaceutical companies (283), medical device manufacturers (384), medical laboratories (807), and research and development laboratories (873). Emphasis is on components of the first two critical categories.

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